



FPNI Ph.D. Symposium on Fluid Power

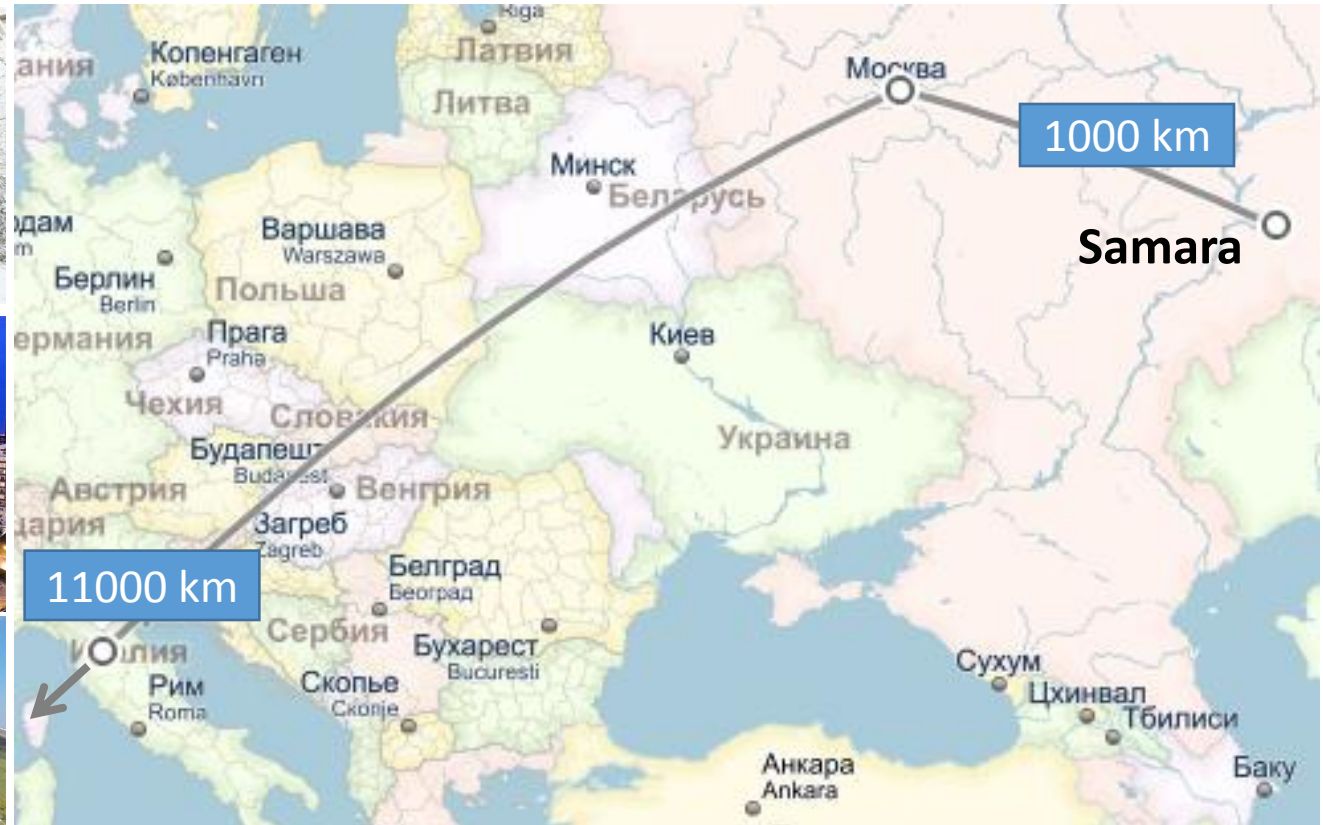
OCTOBER 26-28 · FLORIANÓPOLIS-SC · BRAZIL

2016

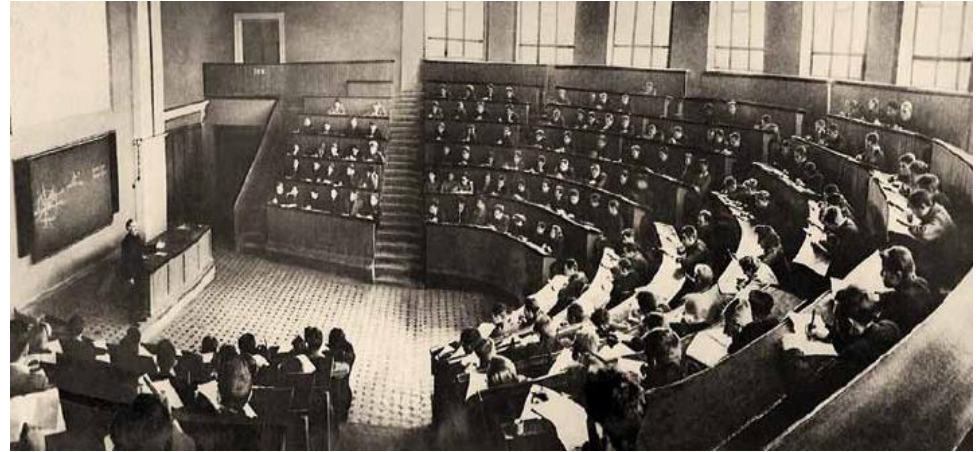
Oscillations suppression in pipe systems by means of compensators

Victor Sverbilov

Samara National Research University
Samara, Russia



THE 74-TH ANNIVERSARY OF SAMARA UNIVERSITY



At the end of 1941 aircraft manufacturing enterprises were evacuated to our city (called Kuibushev at the time) to produce airplanes IL-2 and aircraft equipment. Kuibushev Aviation Institute was established in order to prepare staff for this enterprises. The first students began to study in October 1942 . Today it is Samara University.

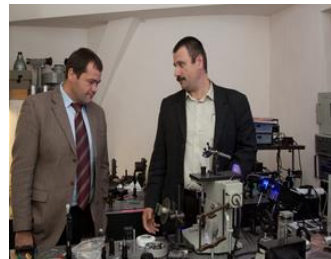
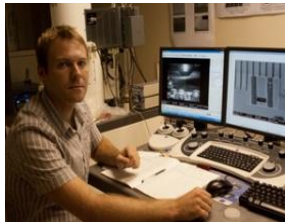


- ❑ *Total 18 000 students, over 1600 lecturers*
- ❑ *102 departments (chairs)*
- ❑ *Media Center with supercomputer S. Korolev*
- ❑ *Total area of buildings 250 000 sq. meters*
- ❑ *Sport complex with 2 indoor swimming pools*
- ❑ *Aviation & Astronautics Museum*
- ❑ *Aviation Engines History Center*
- ❑ *Training Airdrome*
- ❑ *12 dormitories*
- ❑ *Botanical Garden*



ENGINEERING

- ❑ *Aeronautical Engineering Institute*
- ❑ *Aerospace Propulsion Institute*
- ❑ *Computer Science Faculty*
- ❑ *Electronics and Instrumentation Engineering Institute*
- ❑ *Space Engineering Institute*
- ❑ *Industrial Engineering Faculty*
- ❑ *Mechanics and Mathematics Faculty*
- ❑ *Physical Faculty*



SOCIAL SCIENCES & HUMANITIES

- ❑ *Institute of Economics and Management*
- ❑ *Faculty of Basic Training and Fundamental Sciences*
- ❑ *Biological Faculty*
- ❑ *Chemical Faculty*
- ❑ *Historical Faculty*
- ❑ *Psychological Faculty*
- ❑ *Sociological Faculty*
- ❑ *Philological Faculty*
- ❑ *Law Faculty*



MAIN PARTNER ENTERPRISES



САМАРСКИЙ УНИВЕРСИТЕТ
SAMARA UNIVERSITY

Rocket and Space Industry

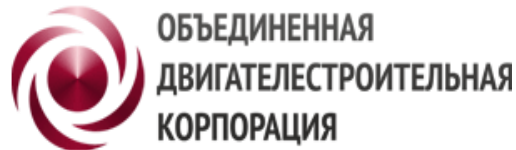


«Souz-U»

«Souz-FG»

«Souz-2»

Jet Engine Industry



«NK-32»



«NK-33»



«RD-180»



«NK-14-ST»



«NK-37»

Aeronautics Industry



«SSJ-100»



«IL-476»



АВИАСТАР-СП



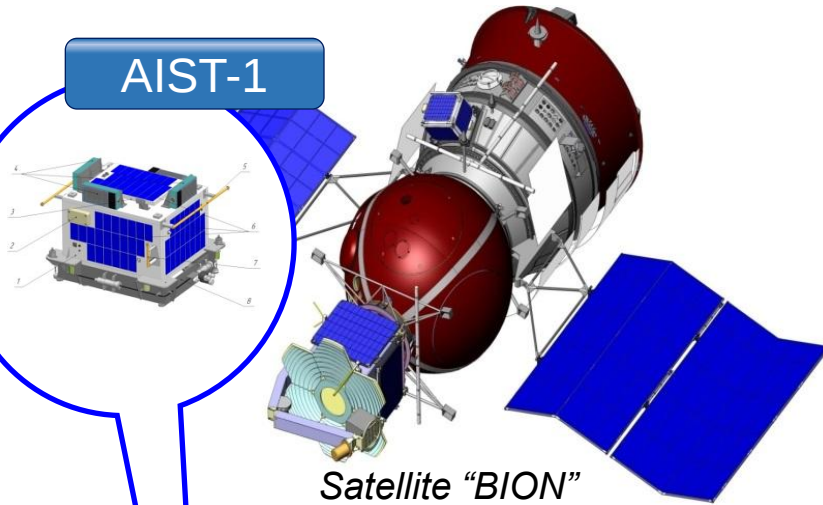
Chassis and units

PROJECTS IN SPACE AND ROCKET AREA



САМАРСКИЙ УНИВЕРСИТЕТ
SAMARA UNIVERSITY

AIST-1



AIST-2



Partner – Rocket and Space Center
“Progress” (Roskosmos)

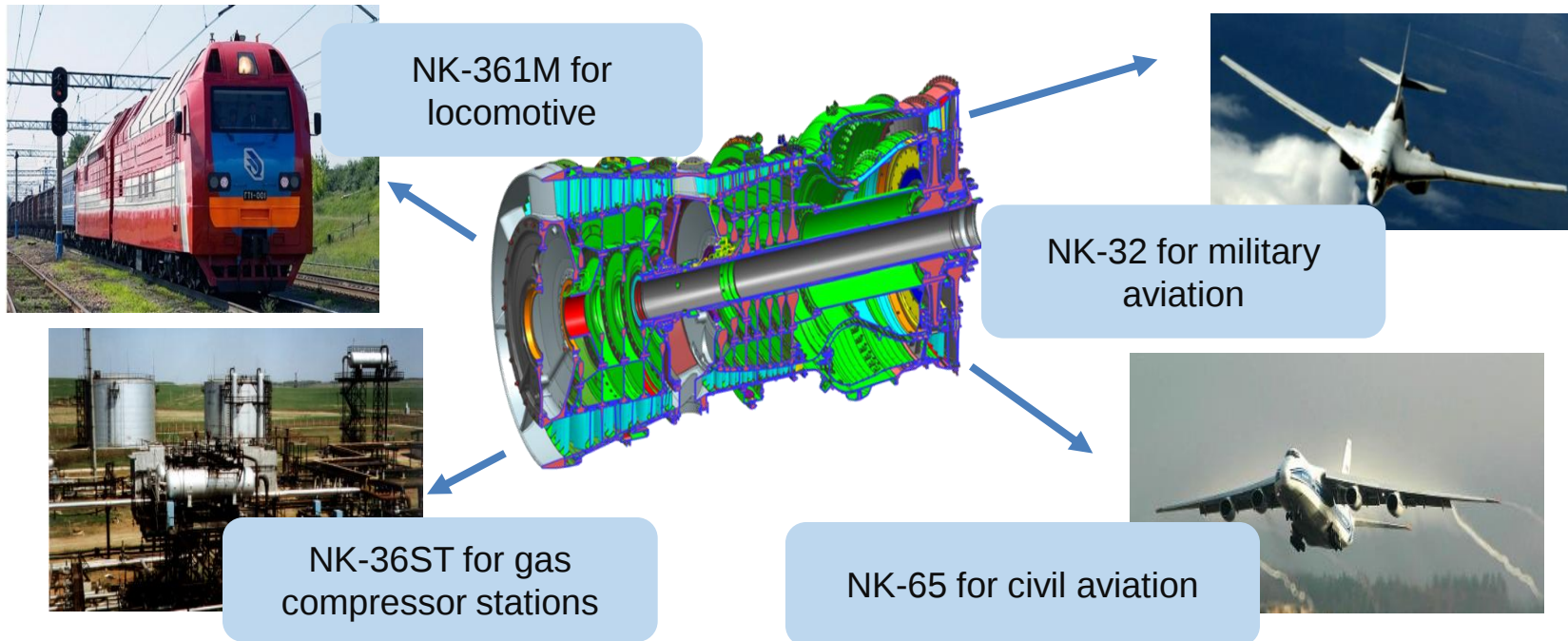
19.04.2013 AIST-1 – Baikonur Launch Complex

28.12.2013 AIST-1 – Baikonur Launch Complex

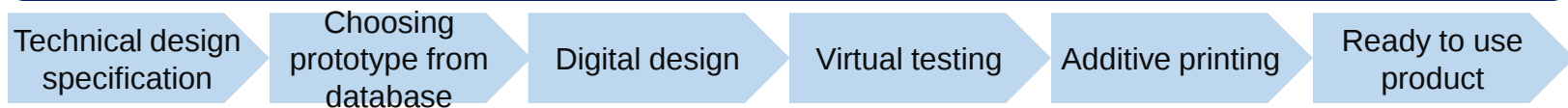
28.04.2016 AIST-2 – Vostochniy Launch Complex



Joint project of gas turbine engine NK-36 engineering together with “Kuznetsov”



Project of engineering and production of small gas turbine engines



Interdisciplinary branch of science including:

- 1) Study on generation and propagation of oscillations in machines as integrated process of interaction:
 - Fluid pulsation / fluid-born noise
 - Mechanical vibration / structure-born noise,
 - External noise / air-born noise
- 2) Developing methods and means of reduction vibroacoustical loading;
- 3) Providing reliability of machines under vibroacoustical loading.



The Laboratory of Pipeline Systems Dynamics

was established in 1960s under the leadership of
Professor Vladimir Shorin

now Academician of Russian Academy (RAS),
Head of Samara Scientific Centre of RAS

His basic work:

*Shorin, V.P., Oscillations Suppression in the Aircraft
Pipeworks, Mashinbuild. Publish., Moscow, 1980,
156 pp. (in Russian).*

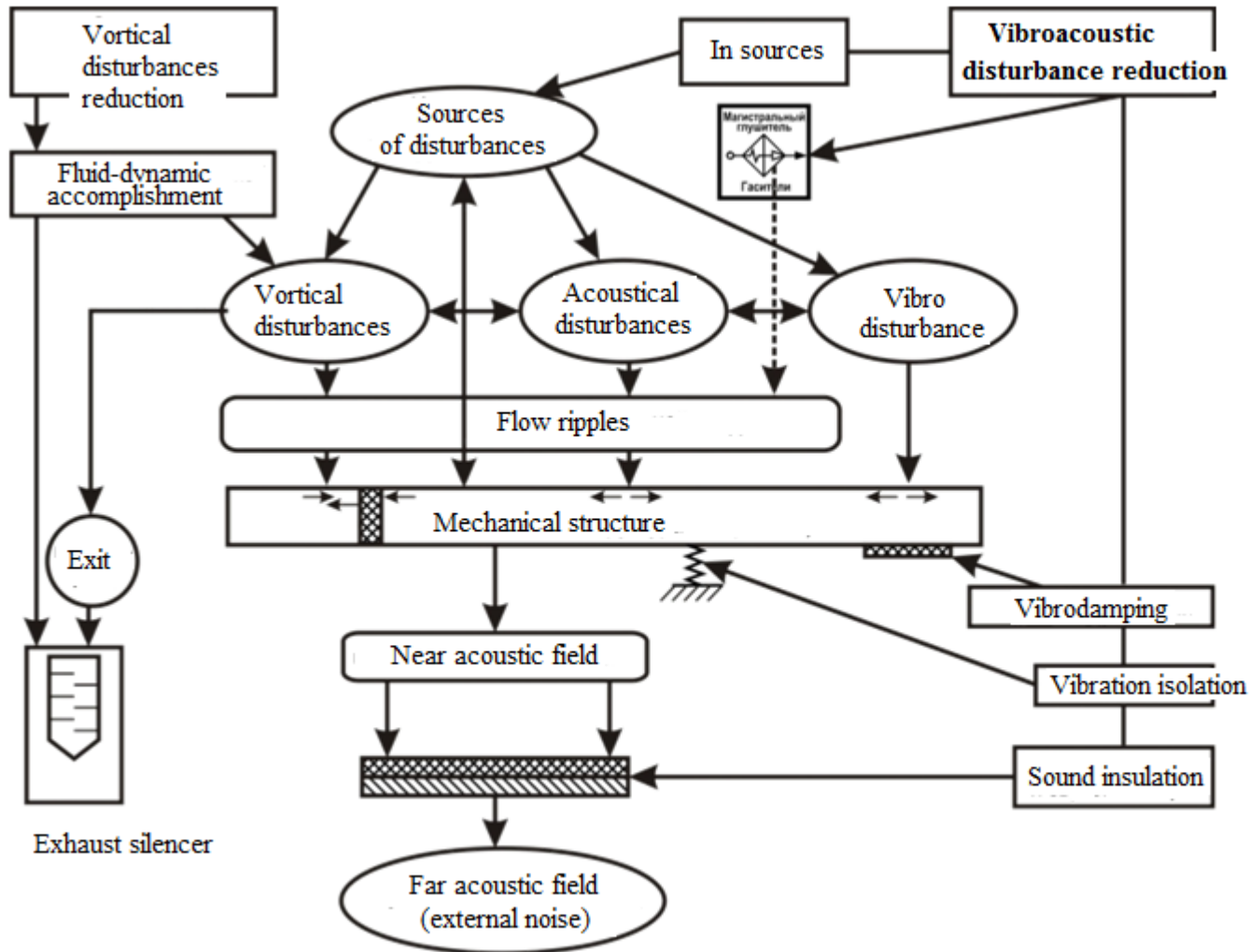


Now the research area is extended, the lab is transformed
into the **Vibro & Acoustic Laboratory**
headed by **Professor Evgeny Shakhmatov**,
Rector of Samara University,
Corresponding Member of RAS

VIBROACOUSTIC PROBLEMS RELEVANCY



COMPLEX APPROACH TO VIBRO ACOUSTIC PROBLEMS



Motivation

Complexity of modern gas and hydraulic systems makes it difficult to predict their dynamic properties at the design stage

During experimental finishing of systems dynamic disturbances frequently occur accompanied by pressure ripples, valves oscillations, noise and vibration being increased without sources of forced oscillations.

There are two principal approach for correction of system dynamic response at the experimental finishing stage:

- to affect the source of oscillations;
- to affect the pipework dynamics.

Motivation

Correcting (compensating) devices of acoustic filters or oscillations damper types are effective means of an influence on pipe lines dynamics.

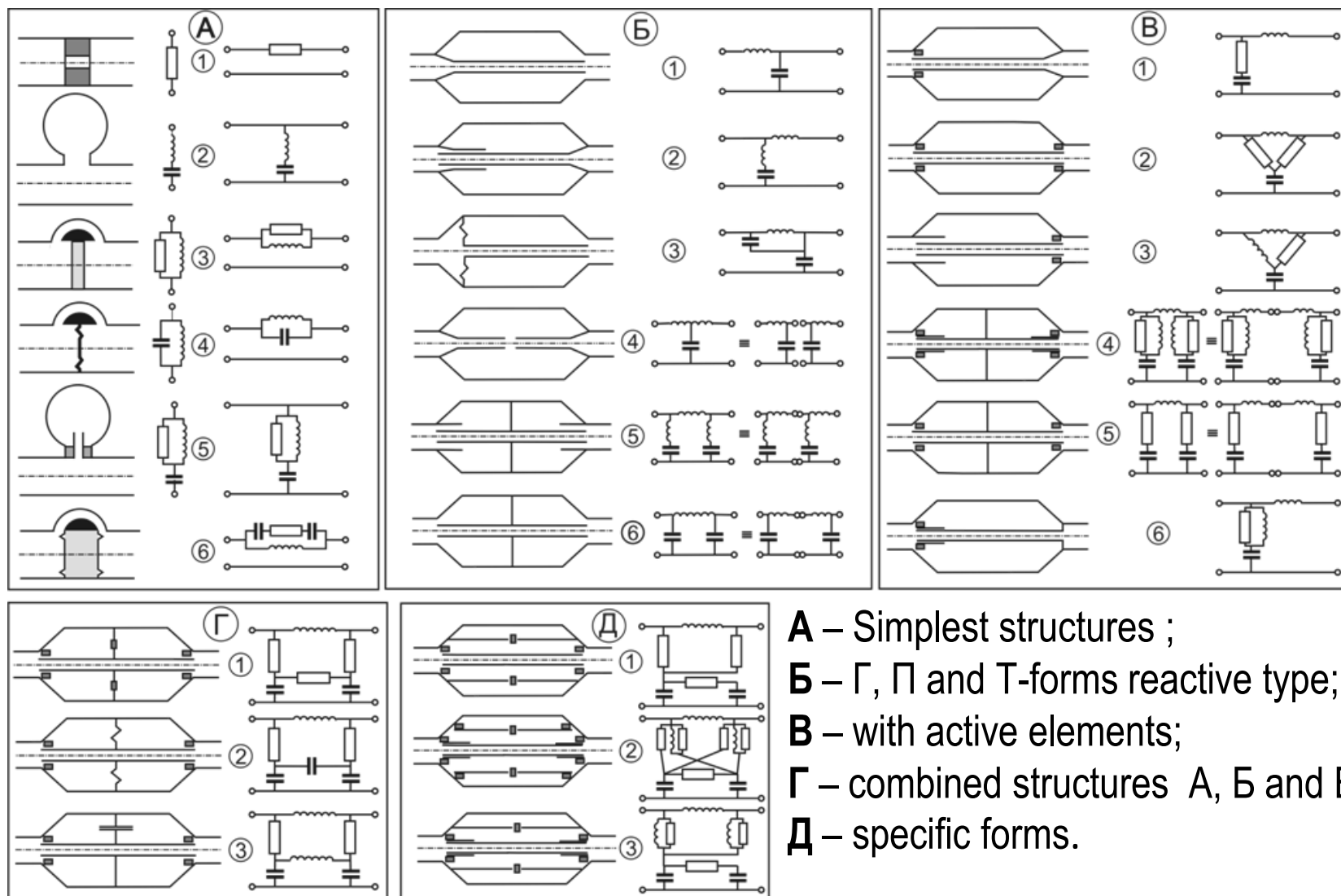
By their application the following problems can be solved:

- -suppressing forced flow oscillations initialized by one or several sources of oscillatory energy;
- -eliminating self-excited oscillations in control systems with flow regulators;
- -increasing an accuracy of measuring pipe lines.

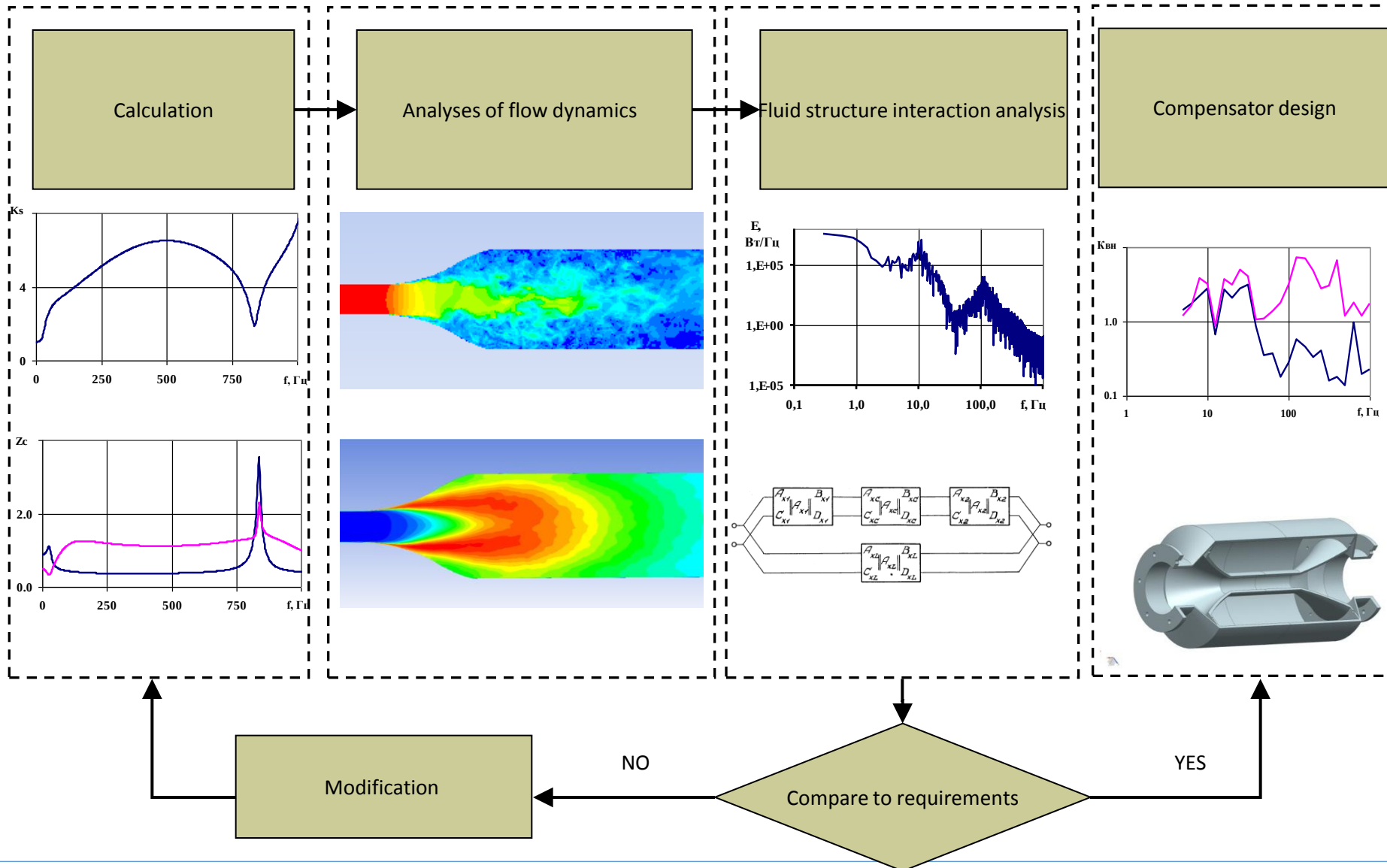
CCLASSIFICATION OF COMPENSATORS



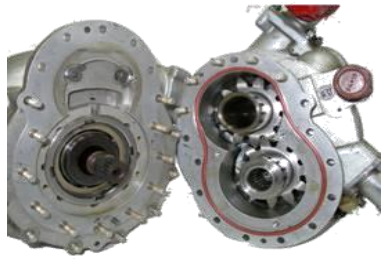
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А – Simplest structures ;
Б – Γ, Π and T-forms reactive type;
В – with active elements;
Г – combined structures А, Б and В;
Д – specific forms.



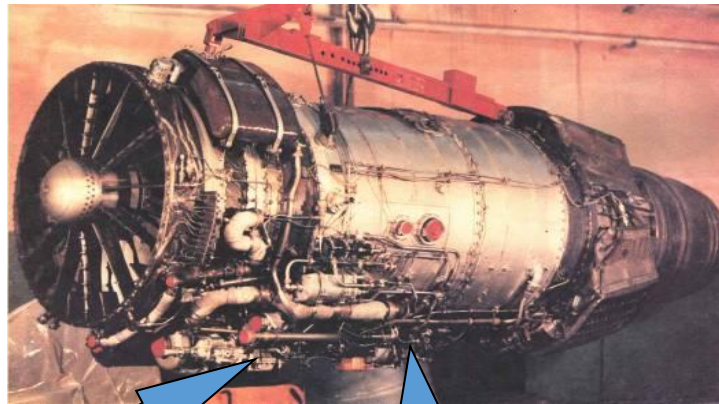
VIBROACOUSTIC LOADS REDUCTION IN AIRCRAFT SYSTEMS



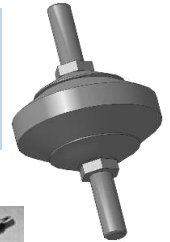
Pump units



Control systems
of aircraft engines



Aircraft hydro
mechanical
systems



Vibration damper



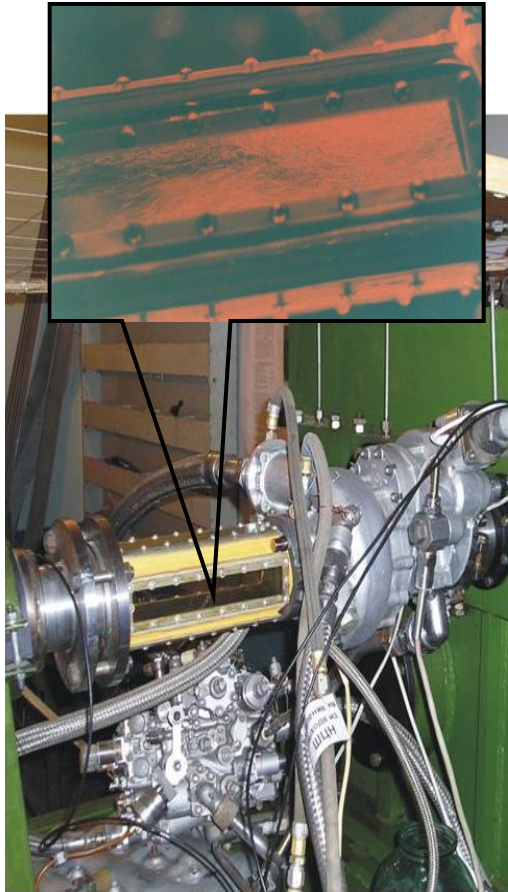
Fluid systems
of test rigs



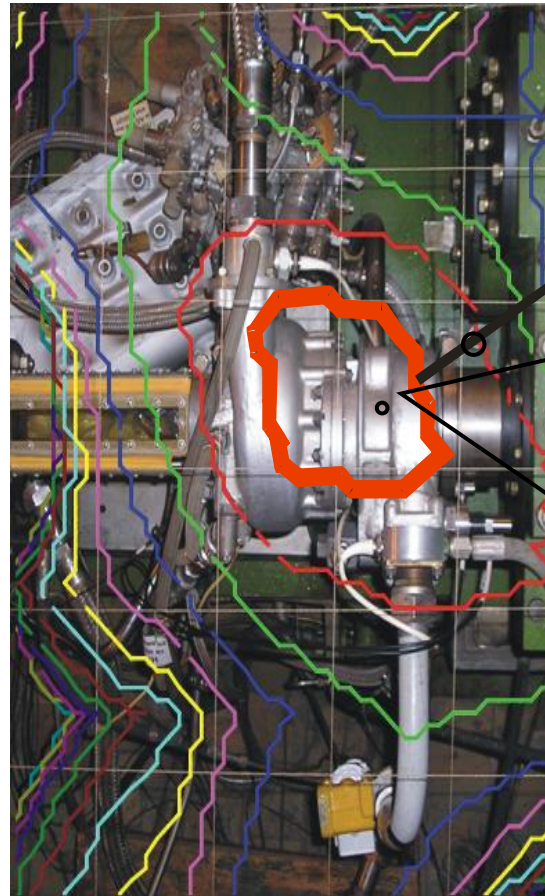
Pressure ripples suppressors



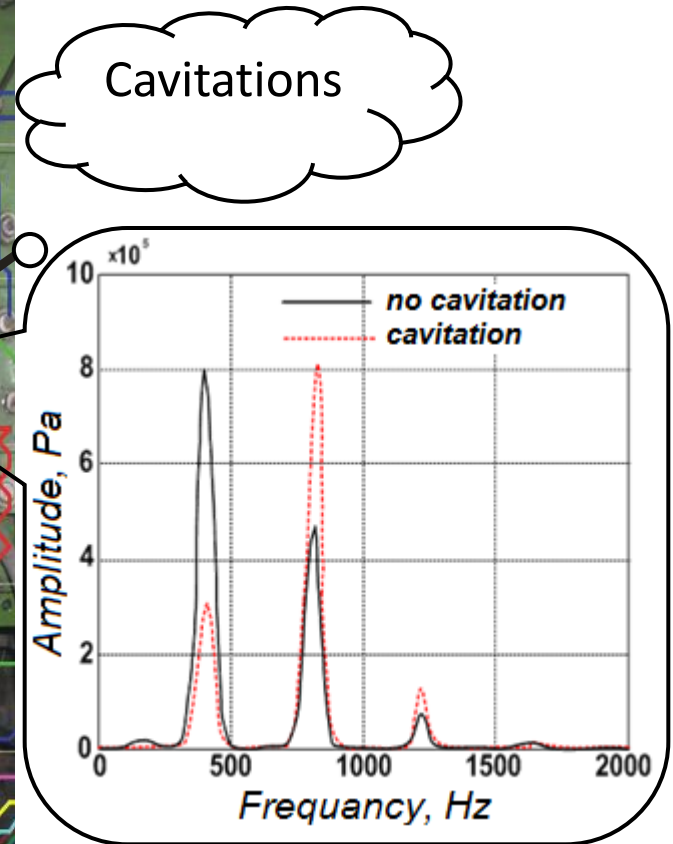
Vibro isolators



Visualisation

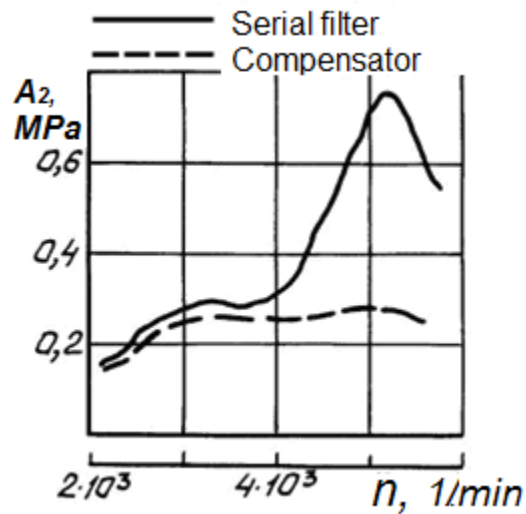
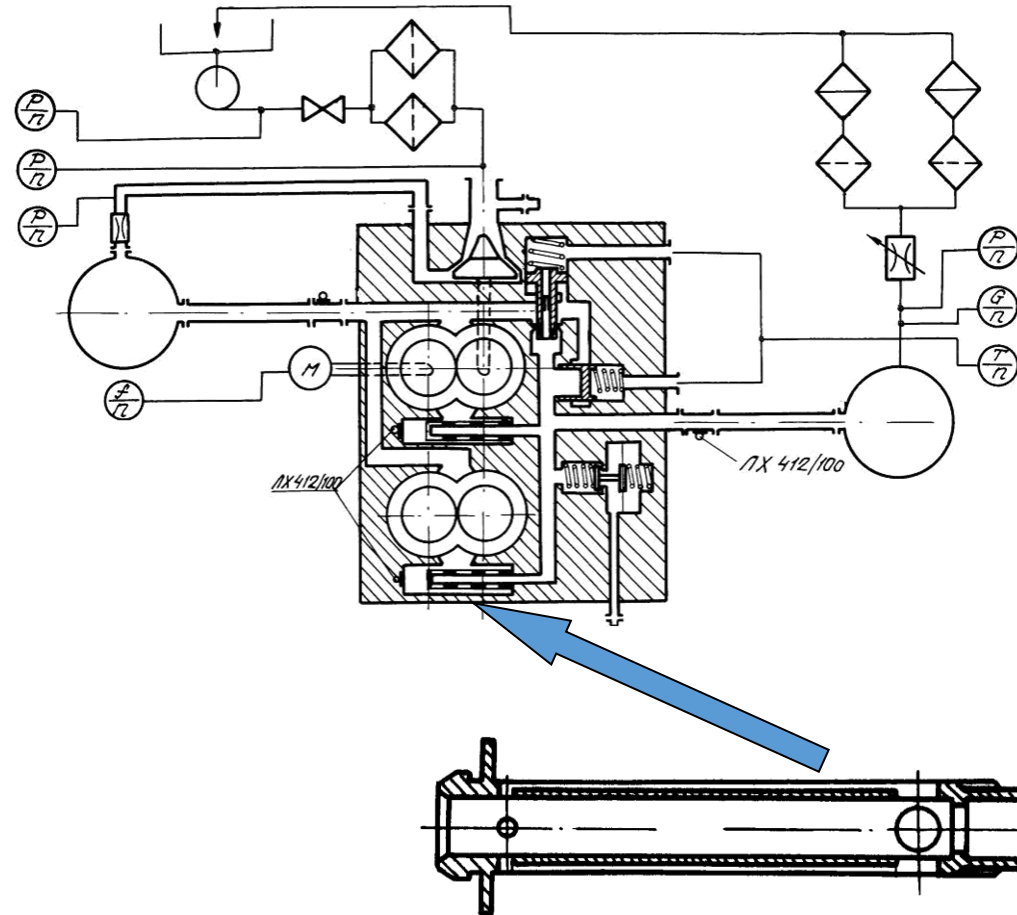


Acoustic intensity map



Cavitations diagnosis

PRESSURE RIPPLES REDUCTION IN CONTROL SYSTEM OF AIRCRAFT ENGINE



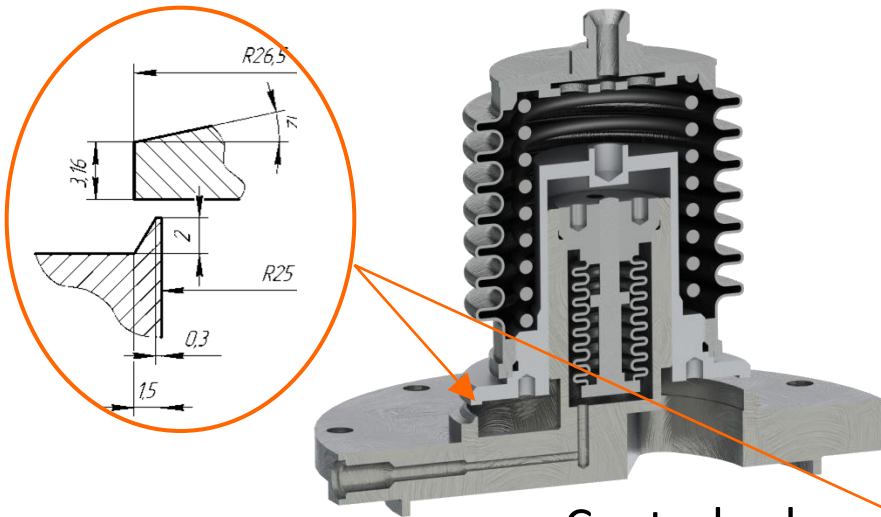
Stability of hydro mechanical control systems can be reached by:

- Proper designing of control units (moving parts damping etc.)
 - forms desirable dynamic properties for specified boundary conditions
 - expensive and not effective for universal units operated in variable boundary conditions
- Acting on a structure and parameters of the attached hydraulic lines
 - forms desirable dynamic properties for specified control units
 - more cheap and independent of boundary conditions

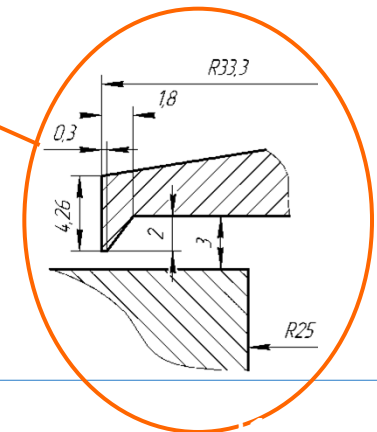
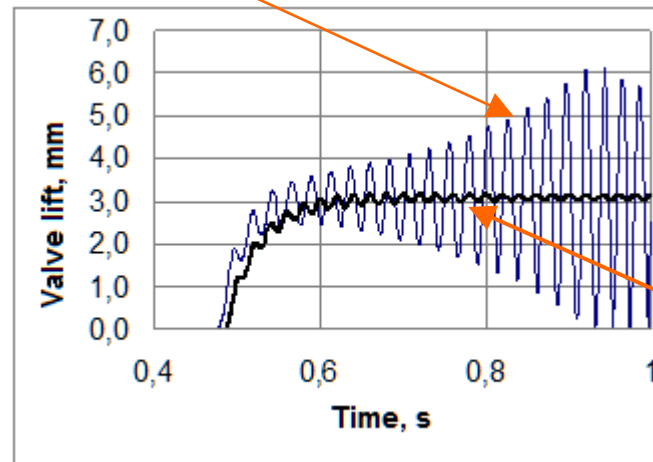
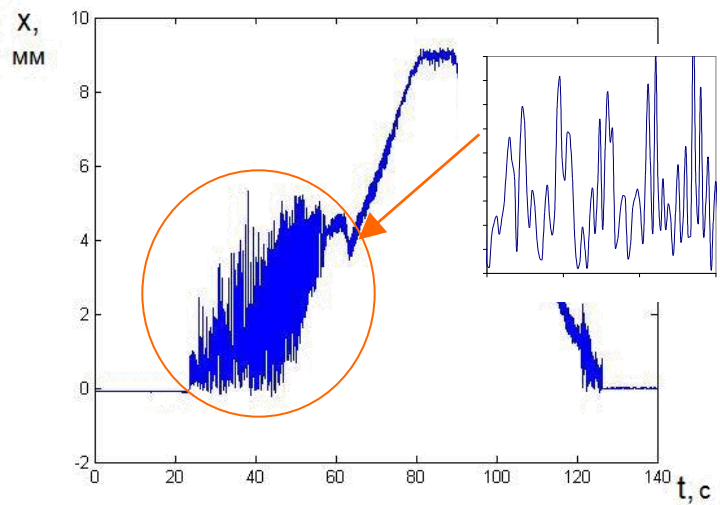
Advantages of the correcting devices:

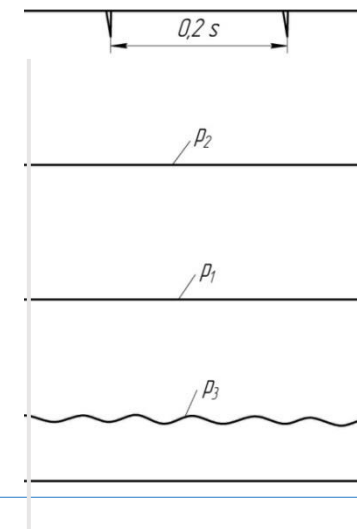
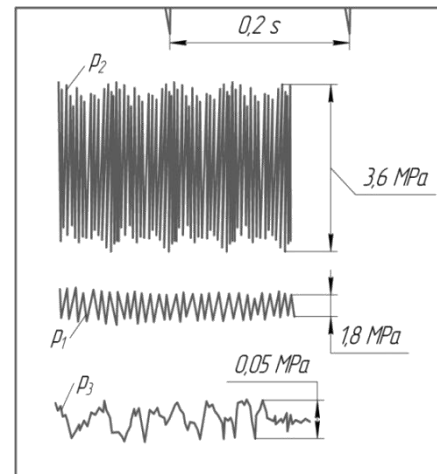
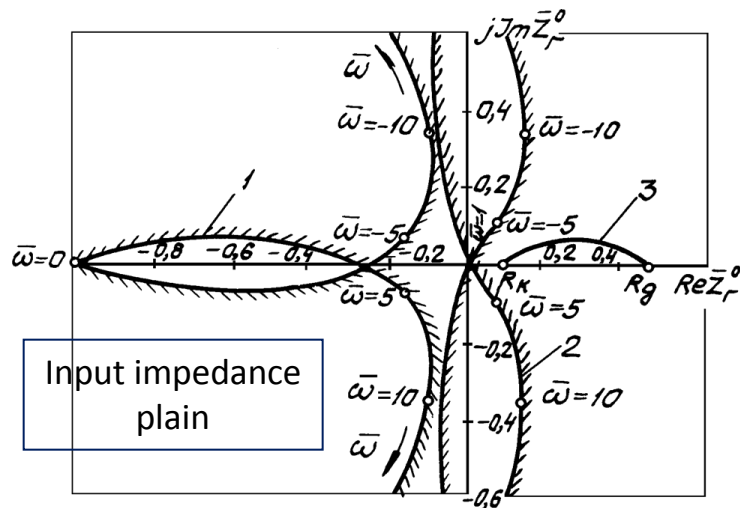
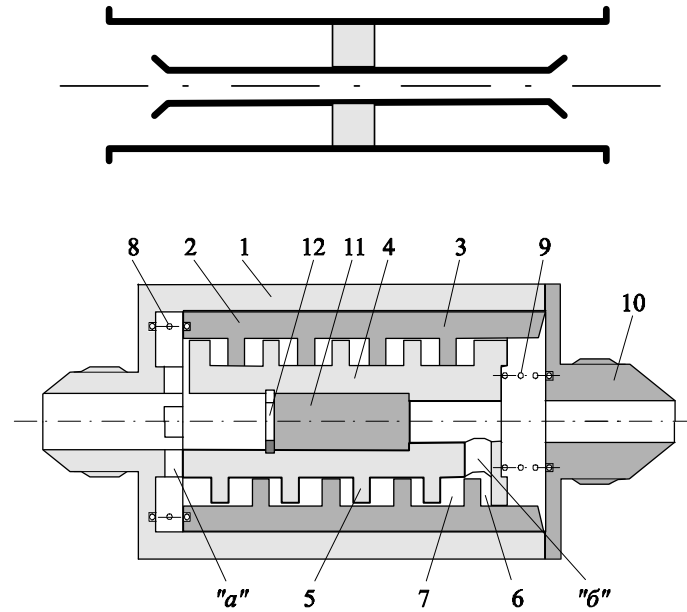
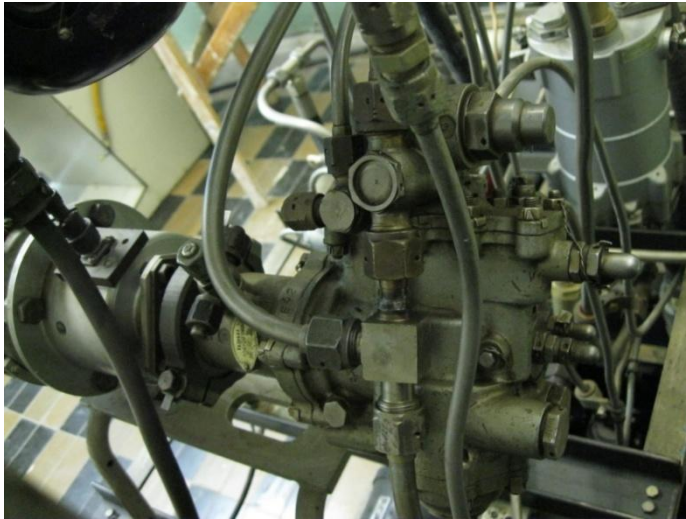
- provides absorption of oscillatory energy
- breaks feedbacks in oscillatory circuits.

PROVIDING STABILITY OF PRESSURE CONTROL

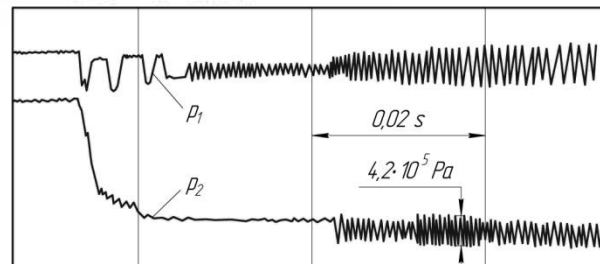
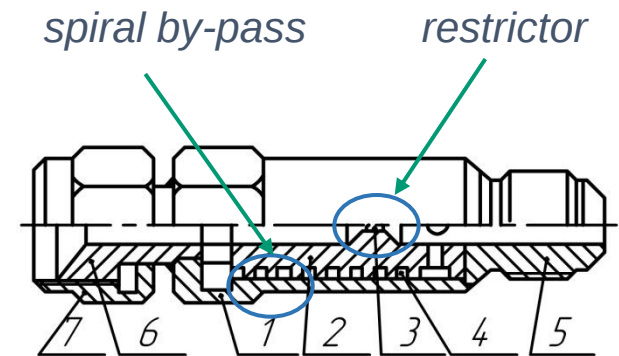
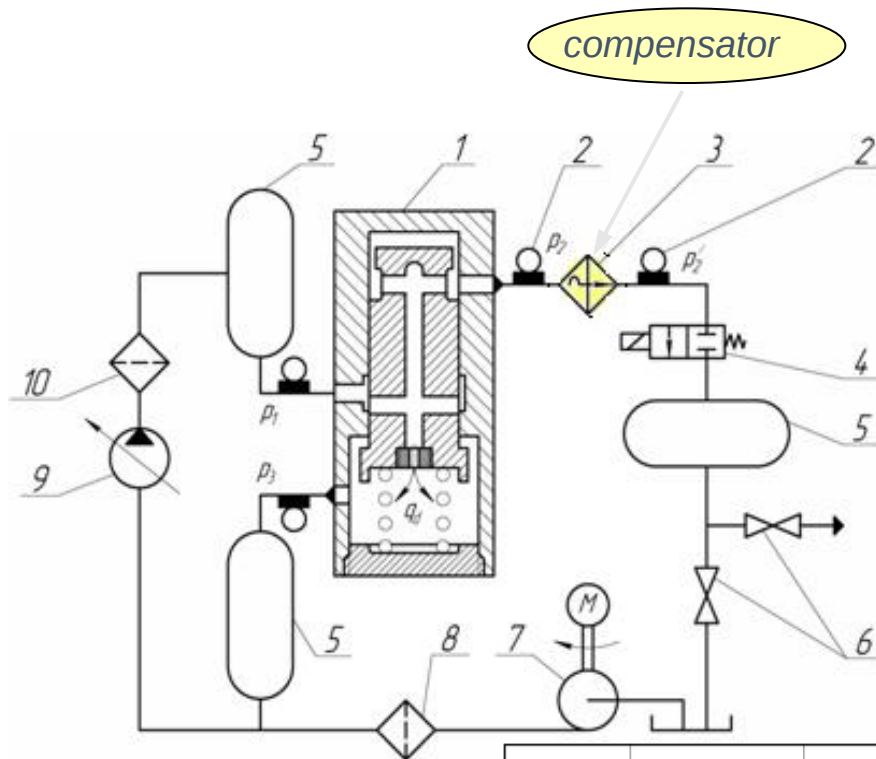


Control valve

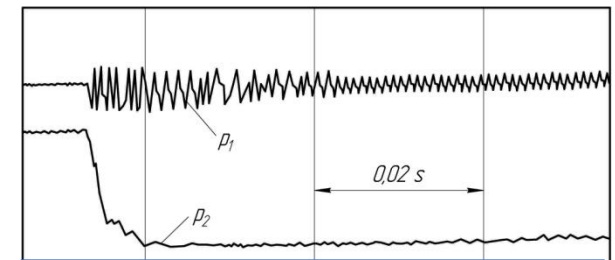




Example



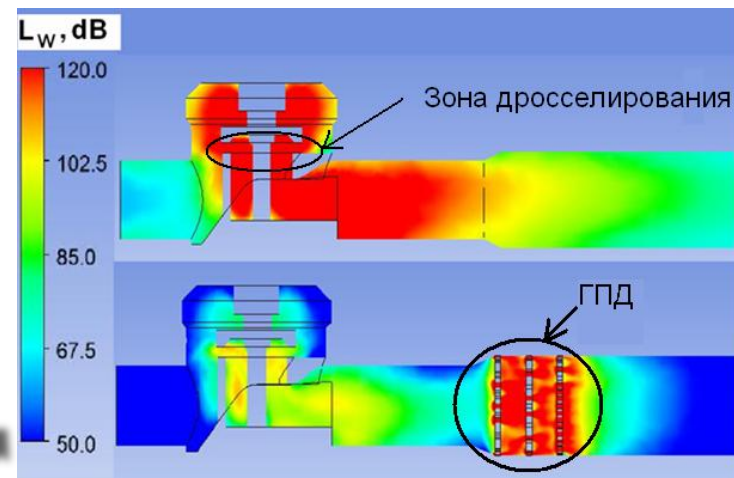
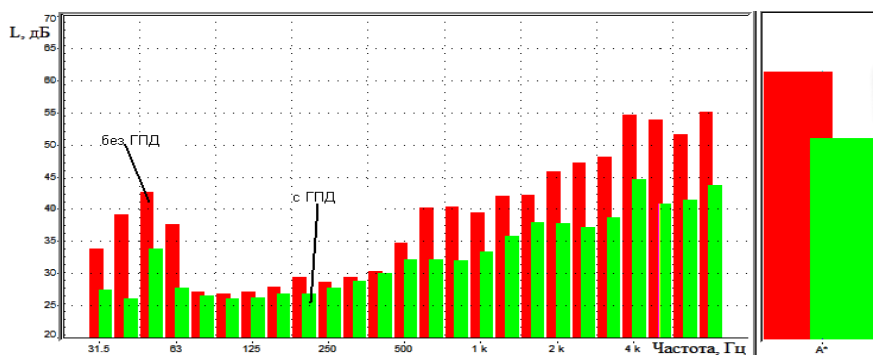
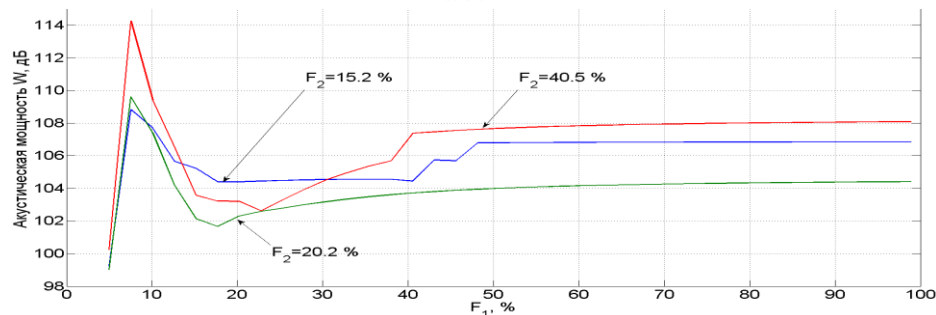
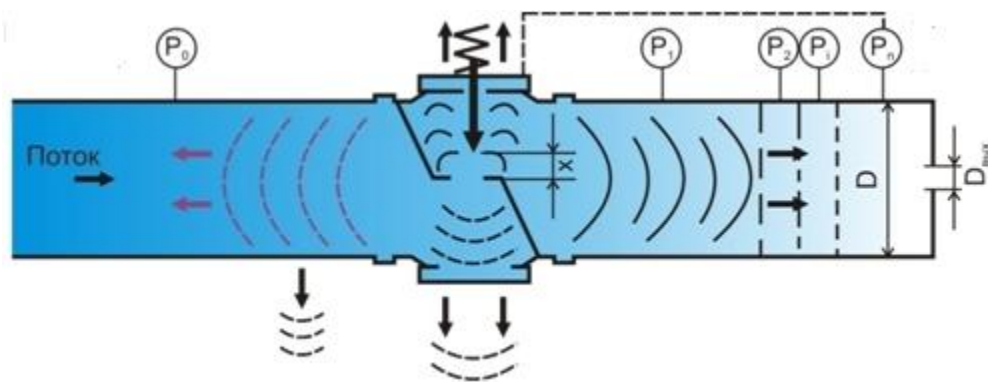
Without compensator



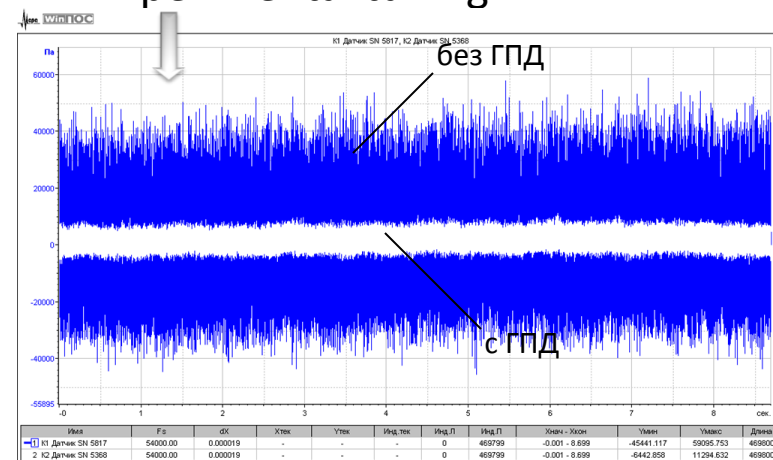
With acoustic **RL** – filter

Developing in-line mufflers of high efficiency for gas distributing stations



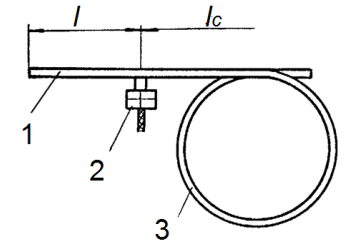
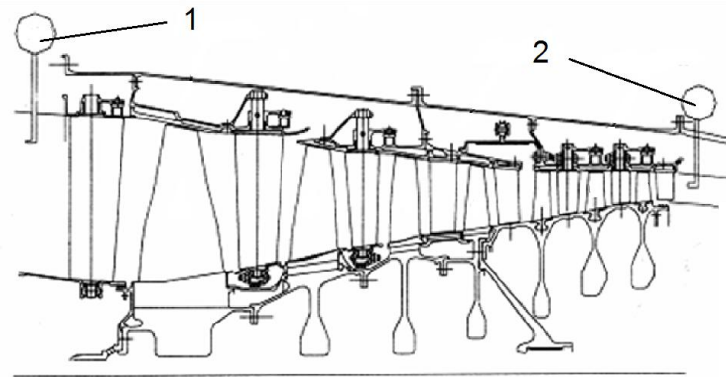


Experimental tuning

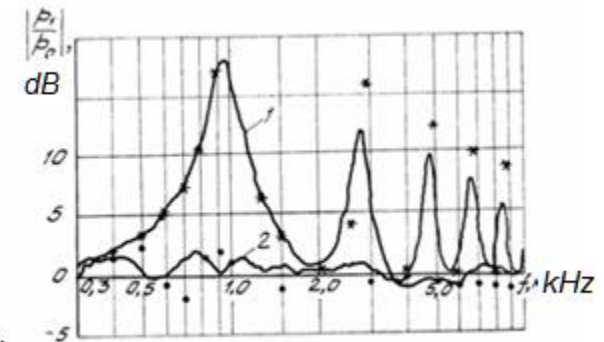
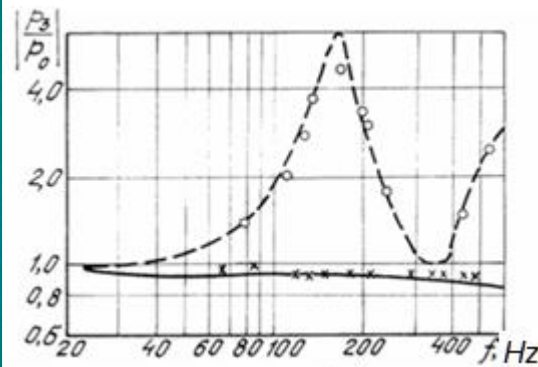


Имя	Fs	dK	Утек	Утек	Утек, тек	Утек, Л	Утек, П	Утек - Утек	Утек - Утек	Утек - Утек	Длина
1) И Датчик SN 5817	54000.00	0.000019	-	-	-	0	409799	-0.001 - 8.899	-45441.117	50095.753	409800
2) И Датчик SN 5368	54000.00	0.000019	-	-	-	0	409799	-0.001 - 8.899	-4442.859	11294.632	409800

ACOUSTIC PROBES FOR PRESSURE MEASUREMENT IN GAS TURBINE ENGINES



Pressure gauges at the input (1) and output (2) of the compressor



Correcting devices / compensators are efficient means of an influence on pipe lines dynamics.

By their application the following problems can be solved:

- suppressing forced flow oscillations;
- eliminating self-excited oscillations in control systems;
- increasing an accuracy of measuring pipe lines.

Acting on a structure and parameters of the attached hydraulic lines they form desirable dynamic properties for specified control units independently of boundary conditions



Thank you for your attention!